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Lessons about Transport and Monitoring at the Vadose Zone Observatory at LLNL*

C.R. Carrigan[1] (925-422-3941; carrigan1@llnl.gov)
G.B. Hudson[1]
S.A. Martins[1]
A. L. Ramirez[1]
W.D. Daily[1]
H.M. Buettner[1]
J.J. Nitao[1]
D.K. Ralston[1,2]
B. Ekwurzel[1]
J.E. Moran[1]
J.F. McCarthy[3]

[1]Lawrence Livermore National Laboratory, L-206, Box 808, Livermore, CA 94550
[2]Defense Nuclear Facilities Safety Board, Washington, DC 20004
[3]Oak Ridge National Laboratory, Box 2008, Oak Ridge, TN 37831

The Vadose Zone Observatory (VZO) at LLNL utilizes a variety of monitoring methods to track controlled infiltration experiments. The unsaturated regime at the site is approximately 60-70 feet in thickness and consists of silt, silty-sand and silty-gravel deposits. Simulations of infiltration treating the deposits as layers, that is, neglecting the potential for 3-D structure, suggest that the vadose zone will function as a formidable barrier to contamination of the water table by a near-surface leak. However, electric resistance tomography (ERT) carried out during infiltration experiments shows that the top and bottom of the unsaturated zone are in good communication. Following the initiation of a near-surface infiltration event, saturation changes are detected just above the water table within a day. Similar results are obtained from gypsum-block tensiometers placed at different levels in a nearby monitoring well. Yet the results of our attempts to track the migration of chemical tracers across the vadose zone show that a significant time lag (~ one month) exists between the detection of saturation changes near the water table and the detectable arrival of the tracers at the water table. During this interim period, water was infiltrated (off and on) until approximately one pore volume had been flushed through the vadose zone. Similar time lags have been observed in our models. We attribute this behavior largely to displacement and dilution effects. At the time of this major flushing event, we also removed the flexible liners in several of the wells surrounding the central infiltration well and examined the borehole walls for evidence of ground water seepage. After days of infiltration, there was no evidence of seepage into the boreholes or flow along desiccation cracks that intersect the boreholes. The lack of flow in boreholes or in cracks in the vadose zone may have significant implications for the

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3. (a) C.R. Carrigan
   L-206
   Geosciences & Environmental Technologies
   Lawrence Livermore Nat. Labs.
   Livermore, CA 94550

   (b) (925) 422-3941
   (c) (925) 422-3118
   (d) carrigan1@llnl.gov

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migration of contamination by colloidal transport. A preliminary and ongoing experiment to test the ability of the vadose zone to inhibit the transport of micron-sized colloids has not resulted in their detection at the water table or at any monitoring level in the unsaturated regime to date.

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